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THE USE OF SOLID CARBON DIOXIDE AS A REFRIGERANT AND AS A SOURCE OF GAS TO SUPPLEMENT STANDARD REFRIGERATION IN THE TRANSPORTATION OF SWEET CHERRIES

Tests made in cooperation with Wenatchee Valley shippers, Great Northern, Chicago, Burlington & Quincy, and Pennsylvania Railroads, Western Fruit Express Company, Cold Control, Inc., and the Standard Railway Equipment Company.

From Wenatchee, Wash., to Philadelphia, Pa., and New York, N. Y., June 14 to June 24, 1940.

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Wenatchee, Wash.
July 15, 1940.

THE USE OF SOLID CARBON DIOXIDE AS A REFRIGERANT AND AS A SOURCE OF GAS TO SUPPLEMENT STANDARD REFRIGERATION IN THE TRANSPORTATION OF SWEET CHERRIES

INTRODUCTION

The studies reported herein are a continuation of those previously discussed in Technical Bulletin 631 and in H.T. & S. Office Report No. 25 pertaining to the use of solid carbon dioxide as a supplement to refrigeration in the storage and transportation of sweet cherries.

As shown in the report of the transportation test conducted in June 1938, the major difficulty to be overcome in the commercial adaptation of carbon dioxide treatments in transit is the leakage of gas in present refrigerator cars. Despite this fact a considerable number of freight shipments of sweet cherries were moved from the Northwest during the seasons of 1939 and 1940 under standard refrigeration supplemented with 500 to 800 pounds of dry ice per car for gas treatment in transit. While shippers in general have expressed satisfaction with the benefits derived from the use of dry ice, the best results cannot be expected until further improvements are made to increase the gas retentiveness of refrigerator cars.

Since the conclusion of the tests made in 1938 certain developments have been made in equipment for the use of solid carbon dioxide as a source of refrigeration and of gas. One such system has come into commercial use, particularly for the shipment of meats and meat products.

OBJECTS OF 1940 TEST

In the transportation test with sweet cherries conducted in June 1940 from Wenatchee, Wash., to eastern terminal markets, further information was sought, particularly on (1) efficiency of the Broquinda system for the use of dry ice as the sole source of refrigeration and of carbon dioxide gas, (2) possible improvement in the gas retentiveness of standard refrigerator cars now in use by lining them with plywood, (3) the feasibility of maintaining desired Co_2 concentrations by additions of solid carbon dioxide en route, (4) air and fruit temperatures as influenced by solid carbon dioxide, and (5) the influence of CO_2 on the color and condition of originally comparable fruit in special test lots at destination.

OUTLINE OF TEST

Description of cars

Of the six cars used in the main test, 3 were of one series, (WFE-100), 2 were of another series (FGE-50000) and the 6th was a car built for the Canadian National Railway (CN-209511). All the cars were of wood construction except CN 209511, which was steel sheathed, with wooden interior. The W.F.E. series cars were 50 feet long with 2 1/2 inches of insulation, while the remaining three were 40-foot cars carrying 4 inches of insulation.

W.F.E. 176 - This car was recently rebuilt in the company shops at Alexandria, Va., especially for use in this test. To increase the gastightness of this car the floor and wall juncture was flashed with asphalt, two layers of asphalt paper were cemented together and placed upon the walls and ceiling, and the entire inner

exposed surface was then lined with 5-ply veneer placed over the usual tongue and groove boards. The inner surface of the car was finally finished with two coats of shellac to insure additional gas-tightness. The main charge of solid carbon dioxide was carried in a crib placed on top of the bracing at the center of the car. Water ice was carried in basket type bunkers with a capacity of 11,600 pounds.

W.F.E. 131 and 169 - These were standard cars and received no special gas-proofing. The main charge of solid carbon dioxide was carried in a crib placed on top of the bracing at the center of the car. Water ice was carried in basket-type end bunkers with a capacity of 12,600 pounds.

C.N. 209511 - This car has 8 overhead ice tanks or bunkers which practically cover the ceiling and have a capacity of approximately 6400 pounds of crushed ice plus any desired percentage of salt. Each tank is equipped with a brine-retaining valve, which is closed while the car is in use. The cooled air and drip water from moisture condensed on the tanks passes down metal-lined ducts in the sidewalls. The floorracks are constructed with crosswise stringers to facilitate air movement induced by the weight of the columns of cold air in the sidewall ducts. Warm air returns to the ice tanks through a slot along the center of the ceiling baffle.

No dry ice was used in this car.

F.G.E. 50214 - This car has 4 inches of insulation, the same as C.N. 209511 and F.G.E. 51677. It was equipped with the special Broquinda system of refrigeration in which solid carbon dioxide is

used as the sole source of refrigeration. The dry ice was placed in specially-constructed bunkers in each end of the car and used to cool a nonfreezing liquid circulated by a thermostatically controlled, gravity flow through a series of finned coils placed on the upper half of the sidewalls of the car. Hand-operated valves leading from each dry ice bunker and controlled from the roof regulated the escape of the gas into the interior. These gas lines were also equipped with breather pipes whereby excess gas could be by-passed to the outside air.

F.G.E. 51677 - This was a conventional end-bunker car, with 4 inches of insulation. Water ice was carried in basket-type end bunkers of 10,160 pounds capacity. No solid carbon dioxide was used in this car.

Location of electric resistance thermometers

	Air temperature	
Top air;	center line;	doorway
Bottom air[1/]	center line;	bunker
	Fruit temperature	
Top fruit;	center line;	bunker
" "	south side;	bunker
" "	center line;	quarterlength
" "	south side;	quarterlength
" "	center line;	doorway
Middle fruit;	center line;	quarterlength

1/ Placed below coils in car 50214 about 48 inches above floorracks. In car 209511 placed at floorrack about 4 feet from end of car.

Bottom fruit;	center line;	bunker
" "	south side;	bunker
" "	south side;	quarterlength
" "	center line;	doorway

Removal of air samples for gas analysis

Air samples for gas analysis were taken at the quarter-length position at the top of the load. In F.G.E. 50214 an additional air-sampling position was maintained at the floorrack level at the doorway. This was done only at the shipper's request since previous results have shown that there is no significant stratification of the gas. Air samples were removed from the interior through one-quarter inch tubing which extended to the exterior of the car at the doorway. The percent of carbon dioxide in the air sample was determined by means of a Hays gas analyzer.

Test fruit

In order to have comparable fruit for examination in each of the cars at destination, special test boxes were prepared prior to loading. Two different maturities were included, being selected from lots delivered at the warehouse by two growers on the evening of June 12. All of the cherries of the "dark" lot were selected from one load and all those of the "red" lot from another load. Cherries of both maturities were sorted on the morning of June 13, primarily to obtain fairly uniform maturity as indicated by color, but at the same time injured fruits and those not of commercial grade were culled out.

Fruit of the "dark" lot varied from dark red to dark mahogany but included no black fruit. Average soluble solids as determined by refractometer readings on 20 fruits was 22.5 percent. This fruit was of good dessert quality and was considered of about optimum maturity for shipment.

The "red" lot varied from pinkish red to pie cherry red. Average soluble solids was 16.8 percent with a range in individual fruits from 13.2 to 22.2 percent. This fruit was of only fair dessert quality and while some fruit of this maturity is shipped commercially it could not be considered as high quality.

Six boxes of "dark" and six boxes of "red" fruit were commercially packed in standard 15-pound cherry lugs with the regular double face pack. The packed boxes were placed in cold storage at noon on June 13 and remained there until a few hours before the cars were loaded on June 14.

One box of "dark" and one box of "red" fruit was placed in each of the test cars at the completion of loading. The boxes were placed on top of the regular load at the top doorway centerline position and secured in place by stripping to the load. The results secured on these comparable lots should reflect the influence of transit conditions to which they were exposed.

Loading data

All cars were loaded either through tunnels or through a canvas flap built into a temporary car door covering. While all of the fruit was loaded into the cars from cold storage rooms fruit temperatures at loading varied considerably, as shown in Table 1.

Table 1. Loading data for cars of sweet cherries.

Icing and salt record

W.F.E. 176, 169 and 131 were initially iced on the afternoon of June 12 and reiced before loading. F.G.E. 51677 and C.N. 209511 were initially iced the afternoon of June 13 and were not reiced before loading. These cars received salt equivalent to approximately 3 percent of the total ice capacity on the afternoon or evening prior to loading.

Three percent salt was added at reicing stations to all cars refrigerated with water ice except in C.N. 209511 which had 5 percent at most of the reicing stations.

F.G.E. 50214 which was refrigerated entirely with dry ice was charged with 4200 pounds of dry ice on the afternoon of June 13 approximately 13 hours before loading.

Application of solid carbon dioxide

The dry ice used for initial charges and recharging en route is shown in Table 2. All of it was in 50-pound cakes. That used for charges at the bracing was left in the cartons which were stacked two high in the crib and secured to the center bracing.

Table 2. Application of solid carbon dioxide to refrigerator cars.

PRESENTATION OF RESULTS

Standing test: gas retention in W.F.E. 176

A preliminary study of the gas retentiveness of W.F.E. 176 was made before the car was used in the test with sweet cherries. This was done to determine how much solid carbon dioxide is needed to

maintain satisfactory gas concentrations en route. The car was initially iced to capacity with water ice on June 2, 1940 and at 11:30 a.m. next day 523 pounds of solid carbon dioxide in 50-pound express cartons was placed in a bracing at the doorway, and 146 pounds of dry ice in naked, unbroken cakes was placed on the water ice in the bunkers. Air samples for gas analysis were taken at irregular intervals for the next several days. The results of this test are shown in Figure 1.

Figure 1. Retentiveness of W.F.E. 176 for carbon dioxide gas when different initial charges of dry ice were used. Standing test with unloaded car. Wenatchee, Wash.

Figure 1 shows that a maximum carbon dioxide gas concentration of 22 percent was obtained 4 hours after the start of the experiment. During the next 24 hours the gas concentration dropped sharply to 11 percent and remained at this level for the following 42 hours. Evidently the rate of sublimation and leakage out through the car were balanced for this period, but thereafter the gas leakage predominated.

The shorter graph in figure 1 shows the gas concentrations produced when the charge of dry ice was used in the bunkers only. In this experiment four 50-pound naked unbroken cakes of solid carbon dioxide were added to the water ice. The difference between the two curves shows the value of a reserve charge of dry ice at the bracing in the maintenance of a more satisfactory concentration of carbon dioxide within the refrigerator car.

Gas treatment in transit

After completion of loading, solid carbon dioxide was added to the various test cars as indicated in table 2. Gas concentrations of the air within the different cars were determined at irregular intervals during transit from point of origin to destination and are recorded in table 3 and figures 2 and 3.

Table 3. Percent carbon dioxide in refrigerator cars loaded with sweet cherries.

Figure 2. Carbon dioxide concentration in the specially rebuilt car W.F.E. 176, and in a standard car of the same series, W.F.E. 131, while in transit from Wenatchee to eastern destinations.

Figure 3. Carbon dioxide concentration in the Broquinda car F.G.E. 50214 and a standard car, W.F.E. 169 recharged en route while in transit from Wenatchee to New York.

W.F.E. 131 was selected at random. It received no special gas-proofing. It should be considered as a direct check for W.F.E. 176, as both cars carried a similar load of fruit and similar charges of solid carbon dioxide. A comparison of the graphs in figure 2 shows that the alterations made in rebuilding W.F.E. 176 resulted in a significant increase in its ability to hold carbon dioxide gas. The value of this is reflected in the condition of the test fruit from these two cars as shown in table 14, there being much less decay in the more mature test fruit in car 176 than in car 131.

One of the objects of the test was to gain further information relative to the possibility of replenishing the gas supply by

additions of solid carbon dioxide to the water ice en route. This was investigated in W.F.E. 169 which, like W.F.E. 131, was selected at random and received no special gas-proofing. It carried the same bunker charge of dry ice as did the other two cars in this series but only half as much at the bracing. Unfortunately, as was detected en route, W.F.E. 169 proved to be a "leaker."

As shown in table 2 and figure 3, W.F.E. 169 was replenished with solid CO_2 five times en route. Each addition caused a decided rise in gas concentration. Despite this, however, the heavy gas leakage from this car precluded the maintenance of a satisfactory level of gas concentration en route, and much of the value of this particular experiment was lost.

During the present cherry marketing season many shippers availed themselves of facilities for recharging refrigerator cars with solid carbon dioxide en route. This was accomplished by a temporary arrangement between the Liquid Carbonic Corporation and the railroads. While this method of commercially replenishing dry ice en route may result in a more economical use of the sublimated gas than the older method of adding all of the dry ice before the car rolls, it cannot be made wholly satisfactory as long as the refrigerator cars in which it is used are as "leaky" as W.F.E. 169 was in this test.

With the exception of a few hours during one day, F.G.E. 50214, using the Broquinda system of refrigeration, maintained a satisfactory concentration of carbon dioxide gas during the entire transit period. (See figure 3). Results of previous experiments have

proved that optimum storage conditions for sweet cherries are obtained with temperatures of 40° - 45° F. in atmospheres of 20-30 percent carbon dioxide. It is evident from the temperature data, table 9, and from the gas data in figure 3, that F.G.E. 50214 met the above requirements very satisfactorily. In fact, of all the cars tested to date, this is the only one that maintained a satisfactory concentration of carbon dioxide throughout the transit period.

Although the Broquinda system was installed in a F.G.E. car of standard construction it does not necessarily follow that this car itself was more gas-proof than others which have been tested. The superior results obtained with it in the matter of gas concentrations can be explained by two factors characteristic of the system: namely, (a) the large supply of solid carbon dioxide required for refrigeration, and (b) the consequent availability of an adequate supply of the sublimated gas which could be introduced to the interior of the car in amounts sufficient to compensate for the leakage without excessive displacement of air within the car.

Since many cherry shippers were using dry ice for gas treatment of their shipments while they were en route, the same as was being tested in W.F.E. 169 and 131, there was an opportunity to observe the carbon dioxide gas concentrations in several other commercial carloads that were attached to the same train as the experimental cars. However, no temperature records were taken in these cars, they contained no test boxes of fruit, and were given no supervisory control en route. Gas-sampling tubes were placed in them at the doorway and samples of air were withdrawn for

analysis at irregular intervals until the cars were diverted. The dry ice loaded into these cars was as follows: P.R.R. 2900 and W.F.E. 121 received 300 pounds in 50-pound express cartons in the bracing at the doorway and 200 pounds in naked unbroken cakes in the bunkers. P.R.R. 2900 received an additional bunker charge of 220 pounds at Lyndale Junction. W.F.E. 178 had an initial charge of 550 pounds at the bracing and a bunker charge of 200 pounds with no additions en route. The carbon dioxide gas concentrations found in these cars are shown in figure 4 and table 4.

Table 4. Percent carbon dioxide in refrigerator cars loaded with sweet cherries. Auxiliary test data - Wash. 1940-1.

Figure 4. Carbon dioxide concentration in three commercial carloads of cherries which received gas treatment while in transit from Wenatchee, Wash.

These data show a wide difference in gas concentration in P.R.R. 2900 and W.F.E. 121. Both had similar initial charges of dry ice yet in the former over twice as high a maximum concentration of carbon dioxide was attained as in the latter. Had P.R.R. 2900 received a nominal bunker charge of dry ice after about 3 days en route it would have carried a satisfactory gas concentration all during the period of observation. From the results shown in figures 2, 3 and 4 it is evident that differences in the gas retentiveness of present refrigerator cars are so great that definite recommendations for the use of dry ice in such cars can not safely be made.

A study of the gas concentration curves shows a temporarily excessive loss of carbon dioxide from all cars on the 4th day enroute. At this time a head wind of exceptionally high velocity was encountered during the major portion of one day's travel between Williston and Guthrie. This sudden decline in gas concentration probably can be explained on the basis of an increased partial vacuum at the rear of each car which greatly accelerated the rate of diffusion and air movement through the cars. The car least affected by this condition was W.F.E. 176 which not only was especially gas-proofed but also carried a heavy reserve charge of dry ice at the bracing. The Broquinda car, F.G.E. 50214, was affected the most. In this case the valve permitting the escape of carbon dioxide gas from the bunker to the load in the forward part of the car, was closed. The rear valve was open but the increased suction at the rear of the car must have literally pulled the normally escaping gas to the outside of the car before it could diffuse therein. This appears to be a logical explanation because as soon as the forward valve was opened the gas concentration inside the car increased rapidly. As soon as the wind velocity decreased on the evening of June 17, the carbon dioxide gas concentration in all the cars increased sharply. This observation on the relation between wind velocity and gas concentration in refrigerator cars is a factor that should be considered in the future development of the use of dry ice in transit.

Temperature records in transit

This report is concerned principally with the study of carbon dioxide treatments in transit, therefore an extended discussion of the temperature studies is reserved until later. However, complete temperature records of the six cars under observation are presented in tables 5 to 10 inclusive.

Table 5. Temperatures in transit - F.G.E. 51677.

Table 6. Temperstures in transit - W.F.E. 176.

Table 7. Temperatures in transit - W.F.E. 169.

Table 8. Temperatures in transit - W.F.E. 131.

Table 9. Temperatures in transit - F.G.E. 50214.

Table 10. Temperatures in transit - C.N. 209511.

Refrigeration in transit

It was rather difficult to make comparisons of temperatures in cars with reserve charges of solid carbon dioxide and those without such charges since different types of cars were involved. Car 51677, the end-bunker car without dry ice, was shorter than the others, had a smaller bunker capacity, and heavier insulation. Furthermore, it was loaded higher than the three cars of the W.F.E.-100 series which had dry ice at the bracing. Nevertheless, when fruit temperatures in certain positions in each of the cars were compared it appeared that the solid carbon dioxide had an influence on them. Table 11, showing fruit temperatures at three positions in the car, indicates that the fruit temperatures were as low or lower in FGE 51677 (no dry ice)

Table 11. Comparison of fruit temperatures in three cars with solid carbon dioxide and one car with none.

at the bottom bunker position than in any of the three WFE 100-series cars. Fruit temperatures at the top doorway centerline and top quarter-length centerline were significantly higher, however, in 51677 (no

solid carbon dioxide) than in any of the other three cars. This fact indicates that use of solid carbon dioxide lowered the fruit temperatures at these positions.

There is also evidence that the reworking of WFE 176 for gas tightness resulted in lower fruit temperatures, since fruit at the top quarter-length centerline was several degrees lower than in WFE 131 which had the same refrigeration with water ice and the same amount of solid carbon dioxide.

Table 12 shows the total amount of ice and salt added to the cars.

Table 12. Ice and salt added in transit.

from preicing to unloading, and also the quantity of remaining unused at destination. These data show that less ice was consumed in WFE 176 than in either WFE 169 or WFE 131. In spite of the smaller consumption of ice, WFE 176 maintained somewhat lower temperatures than either of the other two cars, indicating, as previously suggested, that the paper and plywood added to WFE 176 for gas proofing had a distinct value for insulation as well. Ice meltage was somewhat greater in WFE 176 than in the check FGE 51677. Differences in insulation, however, make it difficult to determine the comparative efficiency of the ice melted in the two cars. CN 209511 melted 16,113 of the 19,461 pounds of ice added, whereas FGE 51677 actually used only 8,514 of the total of 17,274 pounds added. While temperatures as shown in the tables 5 to 10 were not materially lower in CN 209511 than in other cars, the fruit in this

car was at a higher temperature when loaded, a greater volume of fruit was carried, and the fruit temperatures gradually decreased through the transit period, whereas fruit temperatures in FCE 51677 either remained constant or gradually rose.

Table 13 shows the approximate ice meltage in each of the cars from water ice or dry ice or both.

Table 13. Ice meltage in cars from preicing to unloading.

Condition and appearance of the test fruit at destination.

All cars in the test were unloaded in New York during a period of 9 hours, the test boxes being removed between 5 and 7 P.M. June 23. The boxes were taken to the laboratory the same evening where they remained at ordinary room temperature until the examinations were completed. The test boxes in WFE 176, which was unloaded in Philadelphia, were removed at 12:30 A.M. on June 24, carried to New York by the official observers the same morning and there placed with the other text boxes.

All of the boxes were opened on the face side, in the afternoon of June 24, and the fruit was examined for color and general appearance. The boxes were then relidded and left in the laboratory until the morning of June 26 when a thorough examination was made for color, condition, loss in weight, and decay.

The results of the examinations are shown in Table 14. At both examinations there was a readily discernible difference in color between fruit which had been in CO_2 and that which had not. As shown in the table both the "red" and the "dark" lots which had

Table 14. Condition of fruit in text boxes at unloading and after two days at room temperature.

been carried in F.G.E.51677 and C.N. 209511 had darkened more than those carried in the cars which received some CO_2 treatment. In general, test fruit from the cars having the higher CO_2 concentrations (W.F.E. 176 and F.G.E. 50214) was somewhat lighter than that from cars W.F.E. 131 and 169, although this difference was not apparent in all cases.

No difference in condition of the stems of the test fruit could be associated with carbon dioxide treatment in transit but the influence of maturity was apparent. Stems of all "dark" lots were mostly brown and quite withered at the first examination. Stems of the "red" lots were materially greener than those of the "dark" lots but were somewhat shriveled.

Results of the examination made about 2 1/2 days after unloading showed the same relative differences in color although all lots had darkened to some extent. At this time the "dark" lots from the non-gas-treated cars, C.N. 209511 and F.G.E. 51677, were rather dull looking and darker than is desired according to present commercial standards whereas the "dark" lots from the gassed cars were still bright, attractive and acceptable although the less mature red lots would be preferred. The "red" lots from C.N. 209511 and F.G.E. 51677 without carbon dioxide had darkened enough to be about comparable with the "dark" fruit at the time it was packed, while similar fruit from the gassed cars was considerably lighter in color.

The results on decay in the different lots show that the CO_2 concentrations obtained in F.G.E. 50214 and W.F.E. 176 materially reduced the amount of decay. The "dark" lots from F.G.E. 51677 and C.N. 209511, without CO_2, showed 17.5 and 16.5 percent decay respectively, whereas those from F.G.E. 50214 and W.F.E. 176 with good CO_2 concentrations each showed 1.1 percent decay. "Dark" fruit from cars with lower CO_2 concentrations (W.F.E. 131 and 169) showed 5.8 and 5.1 percent decay at this time.

The "Red" lots quite consistently showed less decay than the dark ones but the relationship between test lots transported under the different conditions was about the same as for the "darks." "Red" lots from F.G.E. 51677 and C.N. 209511 showed 3.5 and 2.6 percent decay respectively whereas those from the cars with the higher CO_2 concentrations (F.G.E. 50214 and W.F.E. 176) showed 0.8 and 1.3 percent respectively.

Data for loss in weight from packing to final examination are also shown in table 14. The values do not appear to be consistent and since the percent of shrinkage was small in all instances no significance can be attached to it in any of the cars.

DISCUSSION AND SUMMARY

For some time to come the transportation of fruits and vegetables in atmospheres of carbon dioxide, if attempted, will of necessity have to be made in present or reconditioned refrigerator cars. The field for improving the gastightness of present equipment apparently has received but little attention from operating agencies. The results obtained within W.F.E. 176 in this test were

definitely encouraging as to what might be accomplished at relatively small expense along this line. The development of the Broquinda system whereby dry ice is used both as a refrigerant and a source of carbon dioxide for preservation of the load proved to be a promising new approach to the problem. The use of an initial charge of dry ice at the bracing and the addition of dry ice to the bunkers at frequent intervals en route appears to be the best method of adapting present cars for gas treatment in transit. At present definite recommendations as to the requirements of dry ice per car are difficult to make, since they must be dependent upon the gastightness of the individual cars. For results of commercial value on sweet cherries, however, a minimum of 800 to 1,000 pounds apparently must be used. The practicability of gas treatment, in the final analysis, depends on the additional cost of the dry ice balanced against the increased sales price receivable for fruit thus treated.

In general the results of this transportation test with sweet cherries show that carbon dioxide gas can be used to advantage even in present refrigerator cars. In test fruit of optimum maturity decay was reduced from 16 or 17 percent in the check cars without gas to approximately 5 percent in those carrying low concentrations and to about 1 percent in cars where higher amounts of carbon dioxide were present for longer periods in transit. Differences in decay between gassed and nongassed cars were less when fruit of minimum maturity was tested.

While fruit transported in atmospheres of carbon dioxide remained brighter than that carried without the gas, greenness and

freshness of stems was more closely associated with temperature and maturity than with the carbon dioxide content of the air in the car. It is apparent from the results obtained in the various experiments conducted to date that in the transportation of mature fruit and of fruit weakened by rain damage or imporper handling practices wherein serious decay may become a factor, definite benefits can be obtained by the use of carbon dioxide gas as a supplement to refrigeration during transit.

Table 1. Loading Data for Cars of Sweet Cherries
Test Trip - Wash. - 1940-1

Item	W.F.E. 176	W.F.E. 131	W.F.E. 169	C.N. 209511	F.G.E. 50214	F.G.E. 51677
Shipper	Northern Fruit	Fruit Sales	Northern Fruit	Wells and Wade	Jim Wade	Jim Wade
Loading Point	Wenatchee	Wenatchee	Wenatchee	Wenatchee	Wenatchee	Wenatchee
Destination	Philadelphia	New York	New York	New York	New York	New York
Date Loaded	6/14	6/14	6/14	6/14	6/14	6/14
Time Started	9:20A	7:20A	7:25A	9:20A	6:15A	4:20A
Time Finished	11:30A	9:20A	9:15P	11:35A	8:40A	6:45A
Car Temp. - Start	27°F	40.5°F	40°F	44.0°F	52.5°F	43.5°F
Car Temp. - Close	41.5°	46°	44.5°	49.5°	43°	43°
Fruit Temperature	38°-41°	43°-45°	39°-42°	47°-49°	41.5°-43°	42°-45°
Fruit Variety	Bing	Bing	Bing	Bing	Bing	Bing
Number of Packages	1624	1576	1624	2080	1576	1472
Weight of Packages	17½ lb.	17½ lb.	17½ lb.	17 ½lb.	17½ lb.	17½ lb.
Layers High at Bunkers	7	7	7	10	7	8
Layers High at Doorway	6	6	6	10	7	8

Table 2. Application of Solid Carbon Dioxide to Refrigerator Cars
Transportation Test - Wash. - 1940-1

Car	Initial dry ice added on water ice in bunkers whole cakes unwrapped Pounds	Initial dry ice placed in crib in bracing - Express cartons unopened Pounds	Additions of dry ice on water ice enroute Whole cakes unwrapped Pounds	Total amount dry ice added per car	Amount dry ice remaining at time of unloading
W.F.E. 176	200	1000	None	1200	None
W.F.E. 131	200	1000	None	1200	None
W.F.E. 169	200	500	6/15 -6:10 P.M. - 186 6/17 - 5:05 A.M. - 202 6/18 -10:45 P.M. - 224 6/20 - 7:00 P.M. - 170 6/22 - 8:30 A.M. - 140 Total 922	1622	10
F.G.E. 50214	Initial dry ice added to bunkers Pounds	Addition of dry ice to bunkers enroute Pounds	Manipulation of CO_2 inlet valve for release of CO_2 into car		
	4200	1332 at Lyndale 6/18 - 10:30 P	6/14 - 9 A.M. - Valve on "B" end opened ½ turn. " " "A" " closed. 6/15 - 4 A.M. - Valve on "B" end closed. " " "A" " " 6/17 -3:30P.M.-Valve on "B" end opened 2 turns. " " "A" " closed. 6/17 -6:30 P.M.-Valves on both ends opened fully.	5532	125

Table 3. Percent Carbon Dioxide in Refrigerator cars loaded with sweet cherries.
Transportation Test - Wash. 1940-1

Station	Date	Time	Car W.F.E. - 176 Hrs.	Car W.F.E. - 176 Percent CO_2	Car W.F.E. - 131 Hrs.	Car W.F.E. - 131 Percent CO_2	Car W.F.E. - 169 Hrs.	Car W.F.E. - 169 Percent CO_2	Car F.G.E. - 50214 Hrs.	Car F.G.E. - 50214 Percent CO_2 Top Load	Car F.G.E. - 50214 Percent CO_2 Bottom Floor Rack	Remarks
Wenatchee	6/14	1:30P	1.5	12.0	3.0	11.0	1.5	6.0	4.5	20.0	21.0	
"	"	3:00P	3.0	15.0	4.5	14.0	3.0	7.5	6.0	21.0	22.0	
Adrian	"	8:00P	8.0	19.0	9.5	12.0	8.0	7.0	11.0	25.0	25.5	
Hillyard	6/15	3:00A	15.0	23.5	16.5	13.5	15.0	9.0	18.0	30.5	31.0	Before reicing
"	"	4:30A	16.5	25.0	18.0	14.0	16.5	9.0				After reicing
Troy	"	10:00A	22.0	20.0	23.0	10.0	22.0	5.0	25.0	27.0	26.5	
Whitefish	"	5:00P MT	28.0	18.0	29.5	8.0	28.0	5.0	31.0	23.0	24.0	Befors reicing
"	"	7:00P	30.0	18.0	31.5	9.0	29.5	8.0	33.0	23.0	24.0	After reicing
"	"	7:30P					30.0	8.0				
Walton	"	10:30P					33.5	13.0	36.5		26.0	
Blackfoot	"	2:00A	37.0	18.5			37.0	11.5				Down grade
Buelow	6/16	9:00A	44.0	18.0	45.5	10.0	44.0	8.0	47.0	23.0	23.5	
Glasgow	"	7:30P	54.5	13.0	56.0	6.5	54.5	5.0	57.5	21.0	21.5	
Williston	6/17	5:00A CT	63.0	14.0	64.5	8.0	63.0	4.0	66.0	22.0	22.0	Before reicing
"	"	5:30A					63.5	9.0				After reicing
"	"	6:00A	64.0	15.0	65.5	9.0	64.0	10.0				After reicing
Ray	"	10:30A					68.0	10.0				
Minot	"	3:30P					73.5	3.0	77.5	5.0	5.0	Strong head wind
Guthrie	"	6:30P	76.5	7.5	77.5	1.0	76.5	1.0	80.5	1.0	1.0	Strong head wind
New Rockford	"	10:00P	80.0	7.5					84.0	8.5	8.5	Wind decreased
Breckinridge	6/18	7:30A	89.5	12.0	90.5	7.5	89.5	5.0	93.5	25.0	25.0	about 8:00P
Willmar	"	4:00P	98.0	10.0	99.0	4.0	98.0	2.0	102.0	17.0	17.5	
Lyndals	"	10:00P							108.0		16.0	
"	"	11:00P							109.0		19.0	
St. Paul	6/19	6:00A	112.0	11.0	113.0	6.0	112.0	9.0	116.0	28.0	28.0	
Savanna	"	8:30P	126.5	9.0			126.5	5.0	130.0	26.0	26.0	
Morton Park	6/20	3:00A	133.0	8.0	134.0	4.0	133.0	4.0	137.0		25.0	
Watts	"	1:00P	143.0	4.0	144.0	2.0						
Columous	"	6:30P MT					147.5	2.0	151.5	16.0		
"	"	7:30P					148.5	4.0				
"	"	9:30P					150.5	7.0				
"	"	11:00P					152.0	7.0	155.0	21.0	21.0	
Pitcairn	6/21	8:30A	161.5	3.0	162.5	2.0	161.5	5.5	164.5	24.0	24.0	
Altoona	"	2:30P					167.5	5.0	170.5		24.0	
Jersey City	6/22	5:30A			183.5	2.0	182.5	3.5	184.5	22.0	22.0	Arrival at Jersey
"	"	6:30P			196.5	0.0	195.5	6.0	197.5	16.0	16.0	city yards

Table 4. Percent Carbon Dioxide in Refrigerator Cars Loaded
With Sweet Cherries
Auxiliary Data to Transportation Test - Wash. 1940-1

Station	Date	Time	Car W.F.E. - 178		Car P.R.R. - 2900		Car W.F.E. - 121		Remarks
			Hrs.	Percent CO_2	Hrs.	Percent CO_2	Hrs.	Percent CO_2	
Wenatchee	6/14	1:30P	3.0	9.0	2.5	12.0	2.5	9.0	
"	"	3:00P	4.5	13.0	4.0	14.0	4.0	10.0	
Wilson Creek	"	9:00P	10.5	15.0	10.0	24.0	10.0	10.0	
Hillyard	6/15	3:00A	16.5	17.0	16.0	26.5	16.0	12.0	
Troy	"	10:00A	23.5	13.5	23.0	19.5	23.0	9.0	
Whitefish	"	5:00P MT	29.5	12.0	29.0	17.0	29.0	7.5	Before reicing
"	"	7:00P	31.5	12.5	31.0	17.5	31.0	7.0	After reicing
Buelow	6/16	9:00A	45.5	13.0	45.0	13.0	45.0	7.0	
Glasgow	"	7:30P	56.0	8.0	55.5	11.0	55.5	4.0	
Williston	6/17	5:00A CT	64.5	8.0	64.0	9.0	64.0	4.0	Before reicing
"	"	6:00A	65.5	8.0	65.0	9.0	65.0	4.0	After reicing
Guthrie	"	6:30P	77.5	1.0	77.5	3.0	77.5	0.0	Strong head wind
Breckenridge	6/18	7:30A	90.5	6.0	90.5	6.0	90.5	2.0	
Willmar	"	4:00P	99.0	4.0	99.0	6.0	99.0	1.5	
Lyndale	"	10:00P			105.0	4.5			
St. Paul	6/19	2:00A	109.0	3.0	109.0	16.0			
"	"	6:00A	113.0	4.0	113.0	20.0			
N. Lacrosse	"	1:30P	120.5	3.0	120.5	22.0			
Savanna	"	8:30P			127.5	12.0			

Table 5. Temperatures in Transit - Car F.G.E. - 51677

Place	Date	Time	Outside Temp	Air Temp Top Door C.L.	Air Temp Bot. Bunk C.L.	Fruit Temperatures Top Bunk C.L.	Top Bunk Side	Top Q. Lgth C.L.	Top Q. Lgth Side	Top Door C.L.	Middle Q. Lgth C.L.	Bottom Bunk C.L.	Bottom Bunk Side	Bottom Q. Lgth Side	Bottom Door C.L.	Fruit Temp Max.	Fruit Temp Min.	Fruit Temp Range
Wenatchee	6/14	9:30A		43.0	23.0	42.0	43.5	44.5	43.5	43.0	43.5	40.0	39.5	42.0	43.0	45.5	39.5	6.0
Appleyard	6/14	3:00P	92	43.5	22.5	41.5	43.0	44.5		43.0	43.0	36.0	34.0	38.0	40.5	44.5	34.0	10.5
Adrian	6/14	8:00P	77	46.0	22.5	42.5	43.0	45.0	42.5	43.0	42.0	31.5	31.0	36.0	38.0	45.0	31.0	14.0
Hillyard	6/15	3:00A	51	44.0	24.5	42.5	43.5	45.0	43.0	43.5	41.5	29.5	29.5	34.0	36.5	45.0	29.5	15.5
Rexford	6/15	2:00P	86	43.0	26.0	41.5	43.0		42.5	42.5	40.5	28.5	29.0	33.5	35.0	43.0	28.5	14.5
Whitefish	6/15	5:00P MT	84	44.0	27.0	41.5	42.5	44.0	42.0	42.5	40.0	28.5	29.0	33.0	35.0	44.0	28.5	15.5
Blackfoot	6/16	2:30A	50	45.0	27.5	42.0	43.0	45.0	42.5	43.0	39.0	28.5	29.5	33.0	35.0	45.0	28.5	16.5
Buelow	6/16	9:30A	77	43.0	29.5	42.0	43.0	44.5	42.5	42.5	39.0	29.5	30.5	33.5	35.5	44.5	29.5	15.0
Wagner	6/16	4:00P	82	45.0	30.0	42.0	43.0		42.0	42.0	38.5	30.0	30.5	34.0	35.5	49.0	30.0	19.0
Williston	6/17	5:00P CT	56	45.0	32.5	43.0	43.5		43.5	43.0	38.5	31.5	32.5	35.0	37.0	47.0	31.5	15.5
Stanley	6/17	12:01P	76	45.0	31.0	42.5	43.0	45.0	43.5	42.5	38.0	31.5	32.5	35.5	37.0	45.0	31.5	13.5
Minot	6/17	3:00P	78	45.0	31.0	42.5	43.0	45.5	43.0	42.5	38.0	32.0	32.0	35.5	37.0	45.5	32.0	13.5
New Rockford	6/17	10:00P	56	46.0	31.5	43.0	43.5	45.5	43.5	43.0	38.5	32.0	32.5	35.0	37.0	45.5	32.0	13.5
Breckenridge	6/18	7:30A	64	43.0	32.5	42.5	43.5	45.5	43.5	43.0	38.5	32.5	33.0	36.0	37.5	45.5	32.5	13.0
Willmar	6/18	4:00P	79	45.0	33.5	42.5	43.0	45.0	43.0	42.5	38.0	32.5	33.0	36.0	37.5	45.0	32.5	12.5
Lyndale Jct.	6/18	9:30P	69	47.0	32.5	43.5	43.5	45.5	44.0	43.0	38.0	33.5	34.0	36.5	38.0	45.5	33.5	12.0
Daytone Bluff	6/19	6:30A	58	44.0	32.0	43.0	44.0	46.0	43.5	43.0	38.5	33.0	33.5	36.5	38.0	46.0	33.0	13.0
N. Lacrosse	6/19	1:30P	68	44.0	33.0	42.5	43.5	45.0	43.5	42.5	38.5	33.0	33.5	36.5	38.5	45.0	33.0	12.0
Savanna	6/19	9:00P	64	45.5	29.5	43.0	43.0	45.5	43.0	43.0	38.5	32.5	33.0	36.0	37.5	45.5	32.5	13.0
Morton Park	6/20	3:00A	54	44.0	31.0	43.0	43.5	46.0	43.5	42.5	38.5	32.5	33.0	36.0	38.0	46.0	32.5	13.5
Columbus	6/20	8:30P ET	68	44.5	32.5	42.5	43.0	45.0	42.5	42.5	38.5	32.5	33.0	35.5	37.5	45.0	32.5	12.5
Pitcairn	6/21	8:30A	66	42.0	32.5	42.0	43.0	46.0	42.5	42.0	38.0	32.5	32.5	36.0	38.0	46.0	32.5	13.5
Huntington	6/21	4:00P	72	43.0	32.5	41.5	42.0	44.0	42.0	41.5	38.0	32.5	32.5	35.5	37.0	44.0	32.5	11.5
Jersey City	6/22	5:30A	52	42.0	32.0	44.5	42.5	44.0	42.0	42.0	38.5	33.0	33.0	35.5	37.5	44.0	33.0	11.0
" "	6/22	6:30P	74	45.0	33.0	41.5	42.5	45.5	42.0	41.5	38.0	33.0	33.0	35.0	37.0	45.5	33.0	12.5
Pier 29	6/23	1:00P	74	44.0	33.5	42.0	43.0	44.5	42.5	42.0	38.0	33.5	34.5	36.0	37.5	44.5	33.5	11.0
" "	6/23	4:45P	71	54.0	34.0	42.0	43.0	45.0	42.5	42.0	38.5	33.5	34.0	36.0	37.5	45.0	33.5	11.5

Table 6. Temperatures in Transit - Car W.F.E. - 176

Place	Date	Time	Outside Temp	Air Temp Top Door C.L.	Air Temp Bot. Bunk C.L.	Fruit Temperatures Top Bunk C.L.	Top Bunk Side	Top Q. Lgth C.L.	Top Q. Lgth Side	Top Door C.L.	Middle Q. Lgth C.L.	Bottom Bunk C.L.	Bottom Bunk Side	Bottom Q. Lgth Side	Bottom Door C.L.	Fruit Temp Max.	Fruit Temp Min.	Fruit Temp Range
Appleyard	6/14	3:00P	92	41.5	21.0	40.5	40.5	40.5	40.5	41.0	39.5	38.0	32.5	38.0	40.5	41.0	32.5	8.5
Adrian	6/14	8:00P	77	42.5	22.0	40.5	40.5	1.0	41.0	41.0	39.0	34.0	28.5	36.5	39.0	41.0	28.5	12.5
Hillyard	6/15	3:00A	51	41.5	23.5	40.5	41.0	41.5	41.5	41.5	38.0	31.5	26.0	34.0	38.0	41.5	26.0	15.5
Rexford	6/15	2:00P	86	39.5	24.0	39.0	40.0	40.5	40.0	40.5	36.5	29.5	25.0	32.0	35.5	40.5	25.0	15.5
Whitefish	6/15	5:00P MT	84	41.0	29.5	39.0	40.0	40.5	40.0	40.5	37.0	29.5	25.5	31.5	35.0	40.5	25.5	15.0
Blackfoot	6/16	2:30A	50	42.0	25.5	39.0	40.0	41.0	40.5	41.0	36.5	29.0	25.5	31.5	34.5	41.0	25.5	15.5
Buelow	6/16	9:30A	72	39.0	26.0	38.0	40.0	40.5	40.0	40.5	36.0	29.0	26.0	31.5	34.0	40.5	26.0	14.5
Wagner	6/16	4:00P	82	41.5	2.65	37.5	39.0	40.5	40.0	40.5	36.0	29.0	25.5	31.5	33.5	40.5	25.5	15.0
Williston	6/17	5:00A CT	56	42.5	28.0	38.0	39.5	41.0	40.5	41.5	36.5	30.5	26.5	33.0	34.0	41.5	26.5	15.0
Minot	6/17	3:00P	78	43.5	31.5	38.5	39.0	41.0	40.5	41.0	36.5	31.0	26.5	33.5	33.5	41.0	26.5	14.5
New Rockford	6/17	10:00P	56	45.5	31.0	39.0	39.5	42.0	41.5	42.0	37.5	32.5	28.0	35.0	34.5	42.0	28.0	14.0
Breckenridge	6/18	7:30A	64	41.0	30.5	38.5	39.5	41.0	41.0	41.5	37.5	32.5	28.5	35.0	34.5	41.5	28.5	13.0
Willmar	6/18	4:00P	79	43.0	31.0	38.5	39.5	41.0	41.0	41.0	37.5	32.5	29.0	36.0	34.5	41.0	29.0	12.0
Lyndale Jct.	6/18	9:30P	69	45.5	31.0	39.0	40.0	41.5	41.0	42.0	37.5	33.5	29.0	36.0	35.0	42.0	29.0	13.0
Daytons Bluff	6/19	6:30A	58	43.0	31.5	39.5	41.0	41.5	41.5	42.0	38.0	33.5	30.5	36.5	35.5	42.0	30.5	11.5
N. Lacrosse	6/19	1:30P	68	42.0	31.0	39.5	40.0	40.5	40.5	42.0	37.5	33.0	30.5	36.0	35.5	42.0	30.5	11.5
Savanna	6/19	9:00P	64	44.5	31.0	40.0	41.0	41.5	41.5	42.5	38.0	33.5	30.5	36.0	36.0	42.5	30.5	12.0
Morton Park	6/20	3:00A	54	43.0	31.0	40.5	41.0	41.5	41.5	42.5	38.0	33.5	31.0	36.5	36.5	42.5	31.0	11.5
Columbus	6/20	6:30P ET	68	43.5	31.5	40.5	41.0	41.0	41.5	42.0	38.0	33.5	30.5	36.5	37.0	42.0	30.5	11.5
Pitcairn	6/21	8:30A	66	41.0	31.0	40.5	41.0	41.0	41.0	42.0	38.0	33.5	31.0	36.5	37.5	42.0	31.0	11.0
Huntington	6/21	4:00P	72	42.0	31.0	40.5	41.0	41.0	41.0	41.5	38.0	33.5	31.0	36.5	37.5	41.5	31.0	10.5
Philadelphia	6/23	11:15P		47.5	32.5	42.0	42.5	43.0	42.5	45.0	38.0	34.0	31.5	36.5	38.5	45.0	31.5	13.5

Table 7. Temperatures in Transit - Car W.F.E. - 169

Place	Date	Time	Outside Temp	Air Temp		Fruit Temperatures										Fruit Temp		
						Top					Middle	Bottom						
				Top Door C.L.	Bot. Bunk C.L.	Bunk C.L.	Bunk Side	Q. Lgth C.L.	Q. Lgth Side	Door C.L.	Q. Lgth C.L.	Bunk C.L.	Bunk Side	Q. Lgth Side	Door C.L.	Max.	Min.	Range
Appleyard	6/14	3:00P	92	46.0	23.5	45.0	45.5	46.0	43.5	44.0	43.5	40.5	37.5	42.5	42.5	46.0	37.5	8.5
Adrian	6/14	8:00P	77	47.0	22.5	44.0	45.0	45.0	43.5	42.0	42.5	34.0	30.0	40.5	40.0	45.0	30.0	15.0
Hillyard	6/15	3:00A	51	44.0	23.5	43.5	44.5	45.0	43.0	40.5	41.5	30.0	27.5	38.5	38.5	45.0	27.5	17.5
Rexford	6/15	2:00P	86	42.5	26.0	41.5	42.0	43.0	42.0	38.5	40.0	28.5	20.5	36.5	36.5	43.0	20.5	16.5
Whitefish	6/15	5:00P MT	84	45.0	26.5	41.5	42.0	43.0	41.5	37.5	39.5	29.0	27.0	30.0	36.0	43.0	27.0	16.0
Blackfoot	6/16	2:30A	50	44.5	29.0	41.5	42.0	43.0	42.0	37.0	39.5	29.0	27.5	30.0	35.5	43.0	27.5	15.5
Buelow	6/16	9:30A	72	41.0	29.0	41.0	41.5	43.0	42.0	37.0	39.5	30.0	28.5	36.5	36.0	43.0	28.5	14.5
Wagner	6/16	4:00P	82	45.5	30.0	41.0	41.0	43.0	42.0	36.5	39.0	31.0	28.5	36.5	35.0	43.0	28.5	14.5
Williston	6/17	5:00A CT	56	44.0	30.5	41.0	42.0	42.5	42.0	36.5	39.0	32.0	30.5	37.5	35.5	42.5	30.5	12.0
Minot	6/17	3:00P	78	46.0	31.0	41.0	42.0	42.5	42.5	36.5	39.5	32.5	32.0	38.0	36.0	42.5	32.0	10.5
New Rockford	6/17	10:00P	56	46.5	31.5	42.0	43.0	43.0	43.0	37.0	39.5	32.5	32.5	38.5	36.5	43.0	32.5	10.5
Breckenridge	6/18	7:30A	64	42.0	32.0	41.5	42.5	42.5	42.5	37.0	39.5	33.5	33.0	39.0	37.5	42.5	33.0	9.5
Wilmar	6/18	4:00P	79	45.5	32.0	41.5	42.0	42.0	42.0	36.5	39.5	33.5	33.0	38.5	37.0	42.0	33.0	9.0
Lyndale Jct.	6/18	9:30P	69	47.5	32.0	42.0	43.0	43.0	43.0	36.5	39.5	34.0	33.5	39.0	37.0	43.0	33.5	9.5
Daytons Bluff	6/19	6:30A	58	44.5	33.0	42.5	43.5	43.0	43.0	37.0	40.0	35.0	34.0	39.5	38.5	43.5	34.0	9.5
N. Lacrosse	6/19	1:30P	68	45.0	32.5	42.5	43.5	43.0	42.5	37.5	40.5	35.5	34.5	40.0	39.0	43.5	34.5	9.0
Savanna	6/19	9:00P	64	48.0	32.0	42.5	43.5	43.5	43.0	37.5	40.0	34.5	34.5	40.0	39.0	43.5	34.5	9.0
Morton Park	6/20	3:00A	54	45.0	32.5	43.0	43.5	43.5	43.0	37.5	40.0	35.0	34.5	40.0	39.5	43.5	34.5	9.0
Columbus	6/20	6:30P ET	68	47.0	32.5	42.5	43.5	43.0	42.5	38.0	40.0	34.5	33.5	39.5	40.0	43.5	33.5	10.0
Pitcairn	6/21	8:30A	66	43.0	31.5	42.5	43.5	43.0	42.5	38.0	40.0	34.0	33.5	39.5	40.0	43.5	33.5	10.0
Huntington	6/21	4:00P	72	45.5	32.0	42.5	43.0	43.0	42.5	38.5	40.0	34.5	33.5	39.5	40.5	43.0	33.5	9.5
Jersey City	6/22	5:30A	52	44.0	31.5	43.0	43.5	43.0	42.0	40.0	40.0	34.0	33.0	39.0	40.0	43.5	33.0	10.5
" "	6/22	6:30P	74	49.0	32.5	43.0	43.5	44.0	42.5	41.0	40.0	34.0	33.0	38.5	40.0	44.0	33.0	11.0
Pier 29	6/23	1:00P	74	47.5	33.0	43.5	44.0	44.0	43.0	42.5	40.0	34.5	33.5	39.0	40.5	44.0	33.5	10.5

Table 8. Temperatures in Transit - Car W.F.E. - 131

Place	Date	Time	Outside Temp	Air Temp Top Door C.L.	Air Temp Bot. Bunk C.L.	Fruit Temperatures Top Bunk C.L.	Top Bunk Side	Top Q. Lgth C.L.	Top Q. Lgth Side	Top Door C.L.	Middle Q. Lgth C.L.	Bottom Bunk C.L.	Bottom Bunk Side	Bottom Q. Lgth Side	Bottom Door C.L.	Fruit Temp Max.	Fruit Temp Min.	Fruit Temp Range
Apolsyard	6/14	3:00P	92	44.5	21.0	42.5	41.5	41.5	42.0	42.0	39.0	40.5	35.0	38.5	38.5	42.5	35.0	7.5
Adrian	6/14	8:00P	77	46.0	20.5	42.5	42.0	41.5	42.0	42.0	38.0	32.0	31.0	36.0	37.5	42.5	31.0	11.5
Hillyard	6/15	3:00A	51	43.0	21.5	42.5	42.0	42.0	42.0	41.5	37.0	29.0	29.0	34.0	37.0	42.5	29.0	13.5
Rexford	6/15	2:00P	86	42.5	23.0	41.0	41.0	41.5	41.0	40.0	37.0	28.0	28.5	33.5	36.5	41.5	28.0	13.5
Whitefish	6/15	5:00P MT	84	44.5	23.5	41.0	40.5	41.0	41.0	40.0	36.0	28.0	28.5	33.5	36.0	41.0	28.0	13.0
Blackfoot	6/16	2:30A	50	45.0	25.5	42.0	41.5	42.0	42.0	40.5	36.5	29.0	29.5	35.0	36.5	42.0	29.0	13.0
Buelow	6/16	9:30A	72	41.5	26.0	41.0	41.0	41.5	42.0	40.0	36.5	29.0	30.0	35.0	37.0	42.0	29.0	13.0
Wagner	6/16	4:00P	82	46.0	27.0	41.0	41.0	41.5	42.0	40.5	36.5	29.5	30.0	35.5	37.0	42.0	29.5	12.5
Williston	6/17	5:00A CT	56	45.0	29.0	42.0	42.0	42.5	43.0	41.5	37.0	30.5	31.5	37.0	37.5	43.0	30.5	12.5
Minot	6/17	3:00P	78	47.0	29.0	42.0	42.0	42.5	43.0	41.0	37.5	31.0	32.5	37.5	38.0	43.0	31.0	12.0
New Rockford	6/17	10:00P	56	47.5	29.5	43.0	43.0	43.0	43.5	42.0	37.0	31.5	32.5	37.5	38.0	43.5	31.5	12.0
Breckenridge	6/18	7:30A	64	43.0	30.0	42.5	43.0	43.0	43.5	41.5	38.0	32.5	33.5	38.0	38.5	43.5	32.5	11.0
Willmar	6/18	4:00P	79	46.5	30.5	42.5	42.5	43.0	43.5	41.5	38.0	33.0	33.5	38.0	39.0	43.5	33.0	10.5
Lyndale Jct.	6/18	9:30P	69	48.0	30.0	43.0	43.0	43.5	44.0	42.5	38.5	32.5	33.5	38.5	38.5	44.0	32.5	11.5
Daytons Bluff	6/19	6:30A	58	45.0	30.5	43.5	44.0	44.0	44.5	42.5	39.0	33.5	34.0	38.5	39.5	44.5	33.5	11.0
N. Lacrosse	6/19	1:30P	68	46.0	31.0	43.0	43.0	43.5	44.0	42.0	39.0	33.5	34.5	38.5	39.5	44.0	33.5	10.5
Savanna	6/19	9:00P	64	48.0	31.0	43.5	43.5	44.0	44.5	43.0	39.0	34.0	34.0	39.0	39.5	44.5	34.0	10.5
Morton Park	6/20	3:00A	54	46.0	31.0	44.0	44.0	44.0	44.5	43.0	39.5	34.0	34.5	39.0	40.0	44.5	34.0	10.5
Columbus	6/20	6:30P ET	68	47.0	30.5	43.5	43.5	44.0	44.5	42.5	39.5	33.5	34.5	39.0	39.5	44.5	33.5	11.0
Pitcairn	6/21	8:30A	66	43.0	30.5	43.0	43.5	43.5	44.5	42.0	39.5	33.5	34.5	39.0	40.0	44.5	33.5	11.0
Huntington	6/21	4:00P	72	45.5	30.5	43.0	43.0	43.5	44.0	43.0	40.0	33.5	34.5	39.0	40.0	44.0	33.5	10.5
Jersey City	6/22	5:30A	52	44.0	30.0	43.5	43.5	44.0	44.0	42.5	40.0	33.5	34.5	38.5	40.0	44.0	33.5	10.5
" "	6/22	6:30P	70	49.0	30.5	43.5	43.5	44.0	44.5	43.0	39.5	33.5	34.0	38.0	39.0	44.5	33.5	11.0
Pier 29	6/23	1:00P	74	47.0	31.0	44.0	44.0	44.5	45.0	42.5	39.5	33.5	34.5	38.5	39.5	45.0	33.5	11.5
" "	6/23	4:45P	71	48.5	31.5	44.5	44.5	45.0	45.0	43.0	39.5	33.5	35.0	38.5	39.5	45.0	33.5	11.5

Table 9. Temperatures in Transit - Car F.G.E. - 50214

Place	Date	Time	Outside Temp	Air Temp. Top Door C.L.	Air Temp. Under refrig. coil side	Fruit Temperatures Top Under Bunk C.L.	Top Under Bunk Side	Top Q. Lgth C.L.	Top Q. Lgth Side	Top Door C.L.	Middle Q. Lgth C.L.	Bottom Under Bunk C.L.	Bottom Under Bunk Side	Bottom Q. Lgth Side	Bottom Door C.L.	Fruit Temp. Max.	Fruit Temp. Min.	Fruit Temp. Range
Wenatchee	6/14	9:30A		43.0	32.0	41.5	43.0	41.5	40.5	40.0	42.0	42.5	42.0	42.5	42.0	43.0	40.0	3.0
Appleyard	6/14	3:00P	92	44.0	34.5	42.0	44.0	41.5	38.0	40.5	43.0	44.0	44.0	42.0	43.0	44.0	38.0	6.0
Adrian	6/14	8:00P	77	44.0	31.5	42.5	44.0	41.0	36.5	40.5	42.5	44.5	45.5	42.0	43.5	45.5	36.5	9.0
Hillyard	6/15	3:00A	51	39.0	31.5	42.5	44.5	41.0	35.0	41.0	42.5	44.5	46.0	41.5	43.5	46.0	35.0	11.0
Rexford	6/15	2:00P	86	36.5	31.5	41.0	43.5	39.5	33.0	40.0	41.5	43.5	45.5	40.0	42.0	45.5	33.0	12.5
Whitefish	6/15	5:00P MT	84	37.0	32.5	41.0	43.5	39.5	33.0	40.0	41.5	43.5	45.0	39.5	42.0	45.0	33.0	12.0
Blackfoot	6/16	2:30A	50	37.0	31.0	40.0	43.0	39.0	32.5	39.0	41.0	42.5	44.5	39.0	40.5	44.5	32.5	12.0
Buelow	6/16	9:30A	72	36.0	30.0	40.0	42.5	38.5	32.5	39.0	41.0	42.5	44.0	38.5	40.5	44.0	32.5	11.5
Wagner	6/16	4:00P	82	37.5	33.0	40.0	42.0	38.0	33.0	38.5	40.5	41.0	43.5	38.0	39.5	43.5	33.0	10.5
Williston	6/17	5:00A CT	56	38.0	33.5	40.0	42.5	38.5	33.5	38.0	40.0	41.5	44.0	38.5	40.0	44.0	33.5	10.5
Stanley	6/17	12:01P	76	38.0	33.5	39.5	42.0	37.5	33.5	38.0	39.5	42.0	43.5	38.0	39.5	43.5	33.5	10.0
Minot	6/17	3:00P	78	38.0	34.0	39.5	42.0	37.5	33.5	38.0	39.5	41.5	43.5	38.0	39.0	43.5	33.5	10.0
New Rockford	6/17	10:00P	56	39.0	35.5	39.5	42.0	38.0	34.5	38.0	39.5	41.5	43.5	38.5	40.0	43.5	34.5	9.0
Breckenridge	6/18	7:30A	64	37.0	34.0	40.0	42.5	38.5	35.0	38.0	39.5	41.5	44.0	39.0	40.0	44.0	35.0	9.0
Willmar	6/18	4:00P	79	37.5	35.0	39.5	42.0	37.5	34.5	38.0	39.0	41.0	43.0	38.5	40.0	43.0	34.5	8.5
Lyndale Jct.	6/18	9:30P	69	39.5	36.5	40.5	43.0	38.0	35.5	38.0	39.0	41.5	43.0	39.0	40.0	43.0	35.5	7.5
Daytons Bluff	6/19	6:30A	58	38.0	34.5	40.0	42.5	38.0	35.5	37.5	39.0	41.5	43.5	39.0	40.0	43.5	35.5	8.0
N. Lacrosse	6/19	1:30P	68	37.5	34.5	40.0	42.0	38.0	35.0	37.5	39.0	41.5	43.5	39.0	40.0	43.5	35.0	8.5
Savanna	6/19	9:00P	64	38.0	35.5	40.0	42.5	38.0	35.0	37.5	39.0	41.5	43.5	38.5	40.0	43.5	35.0	8.5
Morton Park	6/20	3:00A	54	38.0	35.0	40.0	42.5	38.0	35.0	37.5	39.0	41.5	43.0	39.0	40.0	43.0	35.0	8.0
Columbus	6/20	6:30P ET	68	37.5	35.5	40.0	42.0	37.5	34.5	37.0	39.0	41.5	42.5	38.5	39.5	42.5	34.5	8.0
Pitcairn	6/21	8:30A	66	37.0	34.0	40.0	42.0	37.5	35.0	37.5	39.0	42.0	43.0	39.0	39.5	43.0	35.0	8.0
Huntington	6/21	4:00P	72	37.5	35.5	40.0	42.0	37.5	35.0	37.5	39.5	42.0	43.0	38.5	39.5	43.0	35.0	8.0
Jersey City	6/22	5:30A	52	38.5	36.5	40.5	42.0	38.0	36.0	37.5	39.5	42.0	43.0	39.5	39.5	43.0	36.0	7.0
" "	6/22	6:30P	74	40.5	40.5	41.0	42.5	38.5	37.0	38.0	39.5	42.0	43.0	40.0	39.5	43.0	37.0	6.0
Pier 29	6/23	1:00P	74	41.5	40.5	41.5	43.5	40.0	39.5	39.0	40.0	42.5	44.5	41.0	40.5	44.5	39.5	5.0
" "	6/23	4:45P	71	42.5	41.0	42.0	44.0	40.0	39.5	39.5	40.0	42.5	44.5	41.0	41.0	44.5	39.5	5.0

Table 10. Temperatures in Transit - Car C.N. - 209511

Place	Date	Time	Outside Temp.	Air Temp. Top Door C.L.	Air Temp. Bot. side 4ft. from end	Fruit Temperatures Top End C.L.	Top End Side	Top Q. Lgth C.L.	Top Q. Lgth Side	Top Door C.L.	Middle Q. Lgth C.L.	Bottom End C.L.	Bottom End Side	Bottom Q. Lgth Side	Bottom Door C.L.	Fruit Temp. Max.	Min.	Range
Appleyard	6/14	1:45P	92	49.5	42.5	47.5	48.5	47.5	48.0	49.5	48.5	46.0	48.5	47.5	49.0	49.5	46.0	3.5
Adrian	6/14	8:00P	77	45.5	38.5	46.5	47.5	46.0	46.5	48.5	47.5	46.0	47.5	46.0	48.5	48.5	46.0	2.5
Hillyard	6/15	3:00A	51	44.5	37.5	46.0	47.0	45.5	45.5	47.5	47.0	46.0	47.5	44.0	48.0	48.0	44.0	4.0
Rexford	6/15	2:00P	86	42.0	37.5	44.5	45.5	43.5	43.5	46.0	45.5	45.0	45.5	41.0	45.5	46.0	41.0	5.0
Whitefish	6/15	5:00P MT	84	42.5	37.5	44.5	45.5	43.0	43.5	45.5	45.5	44.5	45.0	40.5	45.0	45.5	40.5	5.0
Blackfoot	6/16	2:30A	50	42.0	36.0	44.0	45.0	42.5	42.5	45.5	44.5	44.0	44.5	39.5	44.0	45.5	39.5	6.0
Buelow	6/16	9:30A	72	41.0	36.5	43.5	44.5	42.0	42.5	44.5	44.0	43.5	44.0	39.0	43.0	44.5	39.0	5.5
Wagner	6/16	4:00P	82	41.5	38.0	43.0	44.0	41.5	42.0	43.5	43.0	43.0	43.5	38.5	42.5	44.0	38.5	5.5
Williston	6/17	5:00A CT	56	42.0	37.5	43.5	44.0	41.5	42.0	43.5	43.5	44.0	44.0	39.5	43.0	44.0	39.5	4.5
Stanley	6/17	12:01P	76	41.0	37.0	43.0	43.5	41.0	41.5	43.0	43.0	43.5	43.5	39.0	42.5	43.5	39.0	4.5
Minot	6/17	3:00P	78	41.0	37.0	43.0	43.5	40.5	41.0	43.0	42.5	43.5	43.5	38.5	42.0	43.5	38.5	5.0
New Rockford	6/17	10:00P	56	41.0	37.5	42.5	44.0	41.0	41.0	43.0	42.5	43.0	43.5	38.5	42.0	44.0	38.5	5.5
Breckenridge	6/18	7:30A	64	40.0	36.5	42.5	43.0	40.5	41.0	42.5	42.0	43.0	43.0	38.5	42.0	43.0	38.5	4.5
Willmar	6/18	4:00P	79	40.5	37.0	42.0	42.5	40.0	40.5	42.0	41.5	42.0	42.5	38.0	41.0	42.5	38.0	4.5
Lyndale Jct.	6/18	9:30P	69	40.5	36.5	42.5	42.5	40.5	40.5	42.0	41.5	42.5	42.5	38.5	41.5	42.5	38.5	4.0
Daytons Bluff	6/19	6:30A	58	40.0	37.0	42.0	42.5	40.0	40.0	42.0	41.5	42.5	42.5	38.5	41.0	42.5	38.5	4.0
N. Lacrosse	6/19	1:30P	68	40.0	36.5	41.5	42.5	40.0	40.5	41.5	41.5	42.0	42.5	38.5	41.0	42.5	38.5	4.0
Savanna	6/19	9:00P	64	40.0	36.5	41.5	42.5	39.5	40.0	41.5	41.5	42.0	42.5	38.5	41.0	42.5	38.5	4.0
Morton Park	6/20	3:00A	54	39.5	36.5	41.5	42.5	39.5	40.0	41.0	41.0	42.0	42.5	38.5	41.0	42.5	38.5	4.0
Columbus	6/20	6:30 ET	68	39.5	37.0	41.0	42.0	39.0	40.0	40.5	41.0	42.0	42.0	38.0	40.0	42.0	38.0	4.0
Pitcairn	6/21	8:30A	66	37.0	34.5	40.5	41.0	38.5	39.0	40.0	40.0	41.0	41.0	37.0	39.5	41.0	37.0	4.0
Huntington	6/21	4:00P	72	38.0	36.0	40.5	40.5	38.5	38.5	39.5	40.0	40.5	41.0	37.0	38.5	41.0	37.0	4.0
Jersey City	6/22	5:30A	52	37.0	34.5	40.0	40.5	38.0	38.5	39.0	39.5	40.5	40.5	37.0	38.5	40.5	37.0	3.5
" "	6/22	6:30P	74	38.5	37.0	40.0	40.0	38.0	38.5	39.0	39.0	40.0	40.0	36.5	38.0	40.0	36.5	3.5
Pier 29	6/23	1:00P	74	38.5	36.5	40.0	40.5	38.0	38.5	39.0	39.0	40.5	40.5	37.0	38.5	40.5	37.0	3.5
" "	6/23	4:45	71	39.5	37.5	40.0	40.5	38.0	39.0	39.0	39.5	40.5	40.5	37.5	38.5	40.5	37.5	3.0

Table 11. Comparison of Fruit Temperatures in Three Cars with Solid Carbon Dioxide and One Car with None

Station	Date	Time	Top Doorway Centerline				Top Quarterlength Centerline				Bottom Bunker Centerline			
			Car 169 °F.	Car 131 °F.	Car 176 °F.	Car 51677 °F.	Car 169 °F.	Car 131 °F.	Car 176 °F.	Car 51677 °F.	Car 169 °F.	Car 131 °F.	Car 176 °F.	Car 51677 °F.
Hillyard	6/15	3:00A	41.5	40.5	41.5	43.5	42.0	45.0	41.5	45.0	29.0	30.0	31.5	29.5
Buelow	6/16	9:30A	40.0	37.0	41.0	42.5	41.5	43.0	40.5	44.5	29.0	30.0	29.0	29.5
Williston	6/17	5:00A	41.5	36.5	41.5	43.0	42.5	42.5	41.0		30.5	32.0	30.5	31.5
Breckenridge	6/18	7:30A	41.5	37.0	41.5	43.0	43.0	42.5	41.0	45.5	32.5	33.5	32.5	32.5
Daytons Bluff	6/19	6:30A	42.5	37.0	42.0	43.0	44.0	43.0	41.5	46.0	33.5	35.0	33.5	33.0
Morton Park	6/20	3:00A	43.0	37.5	42.5	42.5	44.0	43.5	41.5	46.0	34.0	35.0	33.5	32.5
Pitcairn	6/21	8:30A	42.0	38.0	42.0	42.0	43.5	43.0	41.0	46.0	33.5	34.0	33.5	32.5
Jersey City	6/22	5:30A	42.5	40.0		42.0	44.0	43.0		44.0	33.5	34.0		33.0

Table 12. Ice and Salt Added in Transit

Place	Date	Time	W.F.E. - 176			W.F.E. - 159			W.F.E. - 131			C.N. 209511			F.G.E. - 51677		
			Ice lbs.	Salt lbs.	Salt percent	Ice lbs.	Salt lbs.	Salt percent	Ice lbs.	Salt lbs.	Salt percent	Ice lbs.	Salt lbs.	Salt percent	Ice lbs.	Salt lbs.	Salt percent
Wenatchee	6/12	5:00P	11600[1]			12600[1]			12600[1]								
"	6/13	2:50P													10160[1]		
"	"	4:00P										6148[1]	192	3			
"	"	8:30P	1200	375	3.2	2100	375	3	1900	375	3					288	2.8
"	6/14	1:30P	1600	51	3	1800	54	3	2100	63	3						
"	"	3:30P										3000[2]	160	5.3	1600	48	3
Hillyard	6/15	4:00A	1500	48	3	1300	39	3	1500	45	3	680[2]	34	5	800	24	3
Whitefish	"	7:00P	731[2]	21	3	586[2]	18	3	940[2]	28	3	1330[2]	40	3	505[2]	15	3
Williston	6/17	6:30A	1039[2]	31	3	887[2]	26	3	852[2]	25	3	2600[2]	130	5	1100[2]	33	3
Willmar	6/18	6:00P	809[2]	24	3	1117[2]	34	3	1096[2]	33	3	1853[2]	93	5	1109[2]	33	3
N. Lacrosse	6/19	2:00P	600	18	3	500	15	3	700	21	3	1200[2]	60	5	600	18	3
Morton Park	6/20	3:30A	100	3	3	200	6	3	200	6	3	250[2]	12	5	200	6	3
Columbus	"	7:30P	600	18	3	680	21	3	800	24	3	1600[2]	80	5	600	18	3
Huntington	6/21	4:00P	1000	30	3	1000	30	3	1000	30	3	800[3]	24	3	600	18	3
Total ice added			20779			22770			23688			19461			17274		
Ice remaining at unloading			10000			10600			10300			3348[3]			8760		
Total ice melted			10779			12170			13388			16113			8514		

[1]Based on yard scale weighings of empty and iced cars.
[2]Actual scale weights.
[3]Estimated weight.
All other weights shown are calculations based on bunker measurement.

Table 13. Ice meltage in cars from preicing to unloading.

Source of refrigeration pounds	WFE 176	WFE 169	WFE 131	FGE 50214	FGE 51677	CN 209511
Water ice	10779	12170	13388	None	8514	16113
Solid carbon dioxide	1200	1612	1200	5407	None	None
Approximate total equivalent 1/ in water ice	13179	15394	15788	10814	8514	16113

1/ For purposes of this calculation one pound of dry ice is equivalent to two pounds of water ice.

Table 14. Condition of Fruit in Test Boxes at Unloading and after Two Days at Room Temperature

Car No.	Car Treatment	Time Car Unloaded	Color	Same Day Unloaded: Condition of Fruit and Stems	Two Days After Unloading: Percent Decay	Two Days After Unloading: Percent Weight Loss	Two Days After Unloading: Condition of Fruit and Stems
W.F.E. 176	Special gas proofing. Initial charge dry ice.	1:00A 6/24	Red	About same shade as reds from #169. Stems mostly green but rather dry.	1.3	.76	About same shade as reds from 131 - bright.
			Dark	Lightest color of dark lots - bright-Stems mostly brown and dry.	1.1	.35	Lightest color of dark lots, bright, good appearance.
W.F.E. 131	Standard car. Initial charge dry ice.	5:00P 6/23	Red	About same shade as reds from #169. Stems mostly green but rather dry.	.8	1.06	Slightly darker than reds from 50214, bright.
			Dark	About same shade as darks from 209511. Stems mostly brown and dry.	5.8	1.07	Slightly darker than dark from 50214. Mostly bright, marketable.
W.F.E. 169	Standard car. Initial charge & Transit re-charge. Dry ice.	5:30P 6/23	Red	Second lightest of red lots. Stems mostly green but rather dry.	2.6	.76	About same shade as reds from 131, bright.
			Dark	About same color as darks from 50214. Stems mostly brown and dry.	5.1	.87	About same shade as darks from 131, mostly bright, good.
C.N. 209511	No CO_2 Top Bunkers	3:30A 6/24	Red	Second darkest of red lots. Stems mostly green but rather dry.	2.6	.40	Second darkest lot of reds. Few fruits almost black. Mostly bright.
			Dark	Second darkest of dark lots. Stems mostly brown and dry.	16.5	.82	Slightly brighter than darks from 51677. Many dull fruits.
F.G.E. 50214	Dry ice refrigeration plus CO_2 discharge in car.	5:30P. 6/23	Red	Lightest color of red lots. Stems mostly green but rather dry.	.8	1.09	Lightest and brightest of red lots. Good appearance.
			Dark	Second lightest of dark lots. Stems mostly brown and dry.	1.1	.99	Second lightest of dark lots. Bright. Good appearance.
F.G.E. 51677	No. CO_2 End Bunkers	6:00P 6/23	Red	Darkest color of red lots. Stems mostly green but rather dry.	3.5	.92	Darkest of red lots. Few fruits almost black. Mostly bright.
			Dark	Darkest color of dark lots. Stems mostly brown and dry.	17.5	1.38	Darkest of any dark lot. Many dull fruits. Too dark for trade.

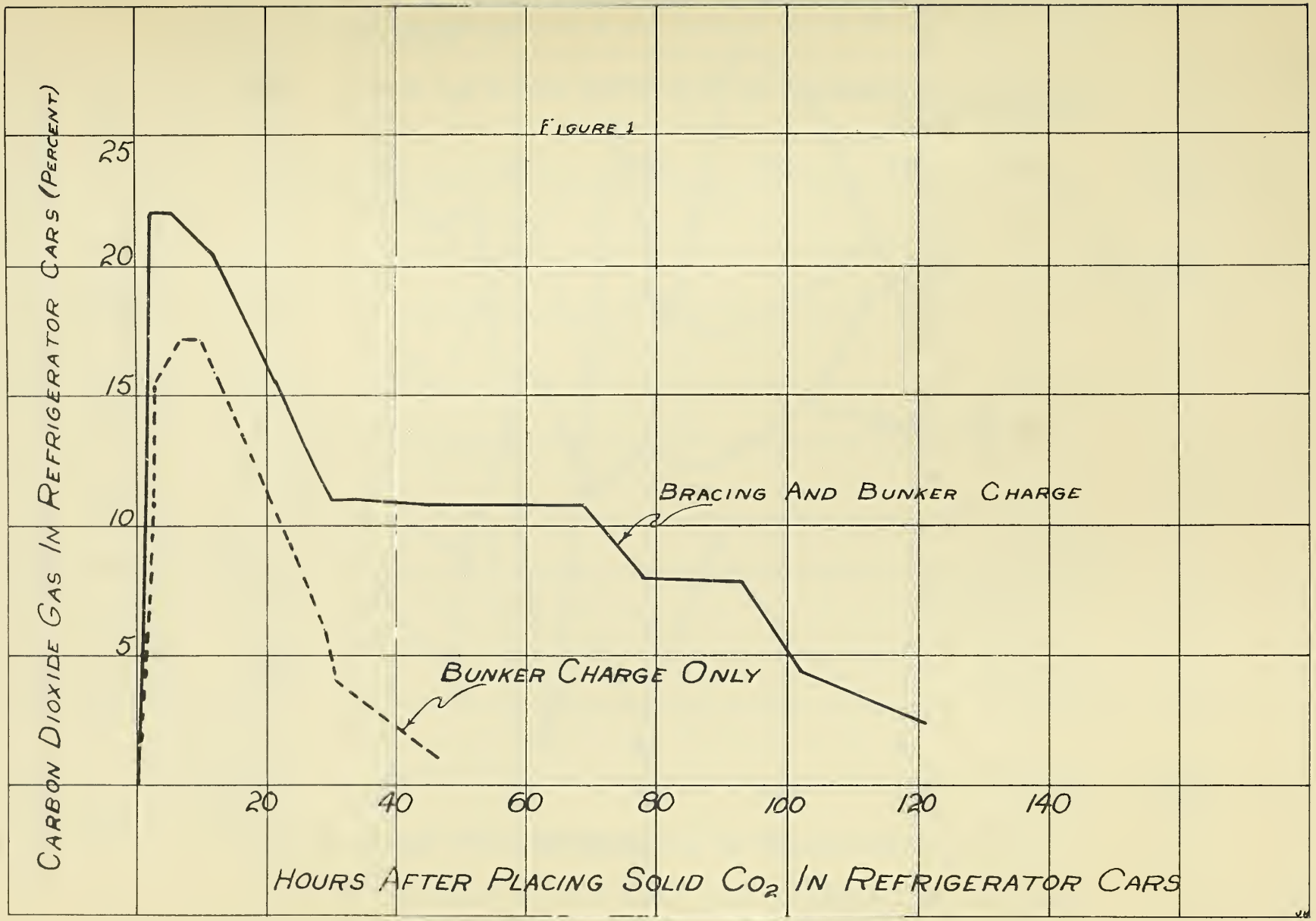

Fig. 1. Retentiveness of W.F.E. 176 for carbon dioxide gas when different initial charges of dry ice were used. Standing test with unloaded car. Wenatchee, Wash.

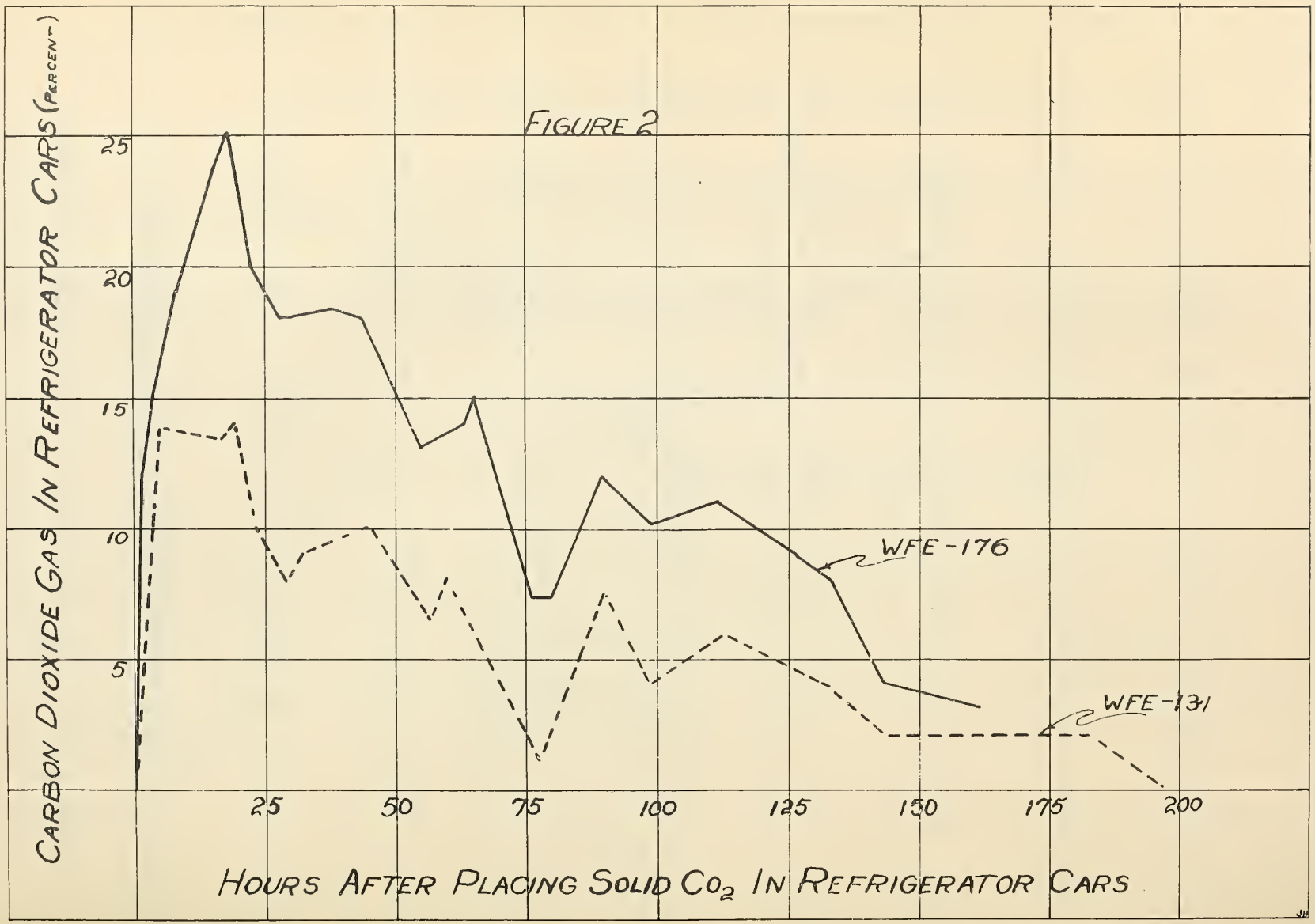

Fig. 2. Carbon dioxide concentration in the specially rebuilt car W.F.E. 176, and in a standard car of the same series, W.F.E. 131, while in transit from Wenatchee to eastern destinations.

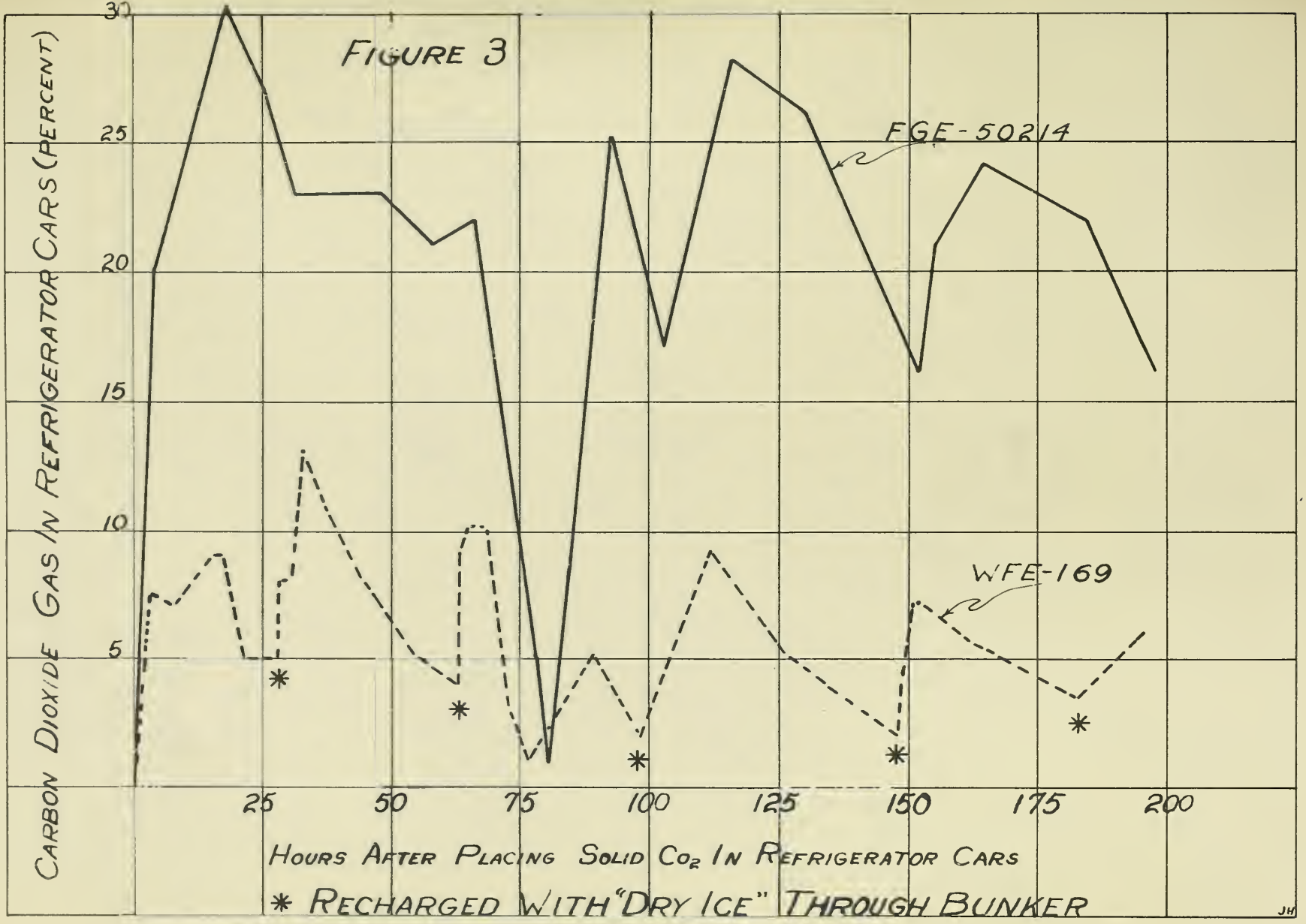

Fig. 3. Carbon dioxide concentration in the Broquinda car F.G.E. 50214 and a standard car, W.F.E. 169 recharged en route while in transit from Wenatchee to New York.

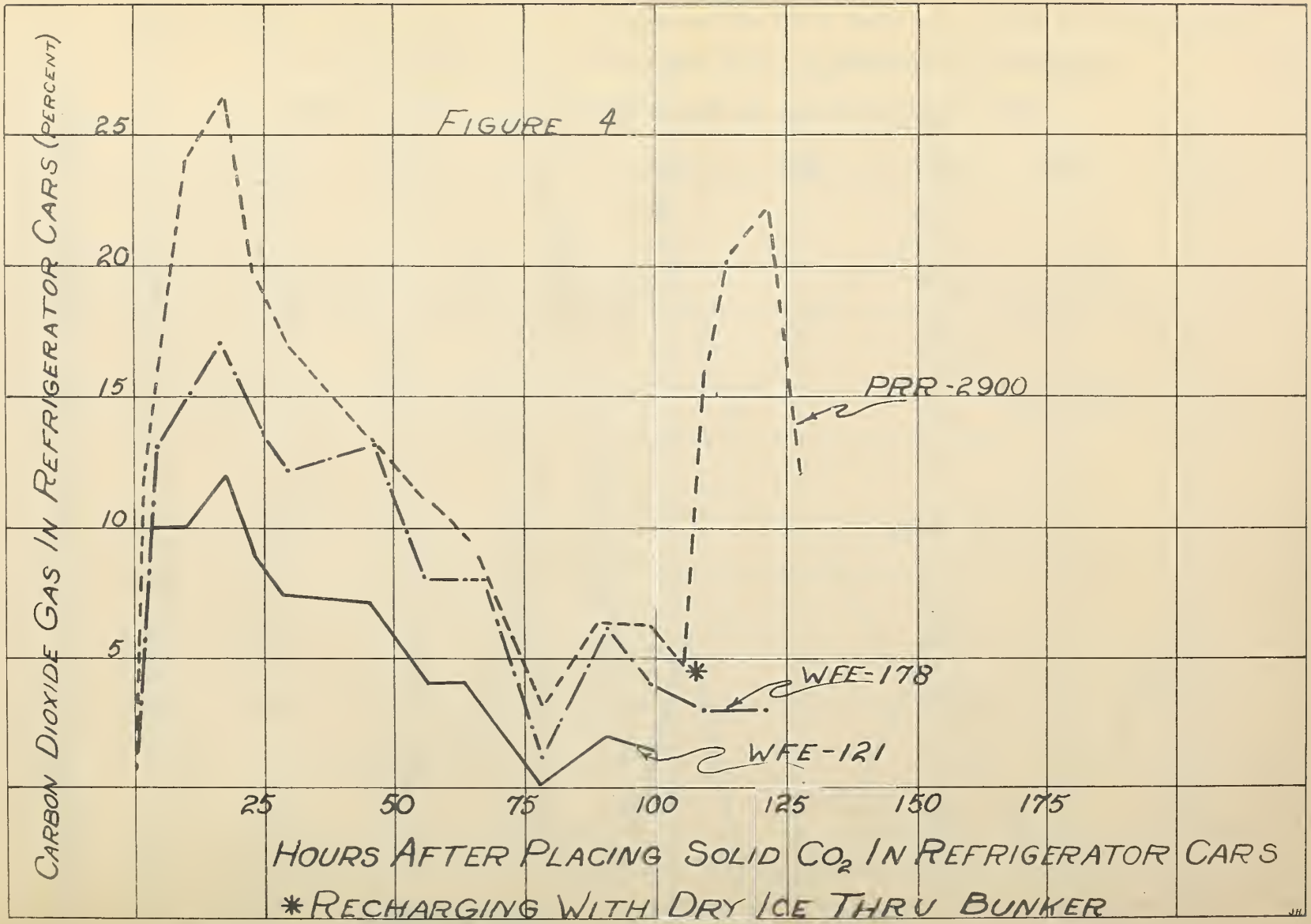

Fig. 4. Carbon dioxide concentration in three commercial carloads of cherries which received gas treatment while in transit from Wenatchee, Wash.